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REMOTE MINE AREA CLEARANCE EQUIPMENT (MACE) C-130 LOAD CELL TEST DATA

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14. ABSTRACT

This report presents the results of the C-130 ramp test of a Hydrema Mine Clearing Vehicle. The test was conducted using a reconfigurable mock C-130 ramp. The objective was to determine if the Hydrema met the C-130 air transportable axle load limitations of 13,000 lbs per axle. Sixteen channels of instrumentation were recorded to determine the weight of the vehicle as it traversed up the test ramp and onto the floor of the plane. In its current configuration the Hydrema exceeded the load limitations of the C-130 aircraft.

15. SUBJECT TERMS

Hydrema, Mine Area Clearance Equipment, C-130 Load Cell Test, MACE, Mine Clearance Vehicle, MCV, C-130 air transportability test of Hydrema MCV or MACE

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1.0 INTRODUCTION

1.1 General

The Air Force Research Laboratory (AFRL) located at Tyndall Air Force Base (AFB) in Panama City FL, has coordinated with the Physical Simulation Team (PST) at the Tank Automotive Research, Development, and Engineering Center (TARDEC) located in Warren MI, to perform a C-130 ramp test on the Hydrema Mine Clearing Vehicle (MCV). This test is being conducted to determine if the Hydrema meets the requirements to be considered C-130 transportable.

The Air Force has strict specifications for loading any vehicle onto a C-130. Those specs state that the axle weights of the vehicle can not exceed 13,000 lbs. This weight limit applies to the ramp of the plane as well as the floor of the aircraft.

1.2 Testing of the System

The test was conducted on July 18, 2007. The test consisted of 10 runs up the instrumented mock C-130 ramp. Four test runs were conducted with the ramp at a 12 degree angle, and 6 runs were completed with the ramp at a 15 degree angle.

The Hydrema vehicle was driven slowly up the ramp shown in Figure 1. The ramp has 16 instrumented plates that are shown as letters A-P. Each plate has four load cells, one in each corner, and is capable of measuring up to a 20,000 lb load. The vehicle made several stops as it climbed the ramp in order to take clear readings of the tire forces at various locations.

In order for the Hydrema to be considered C-130 transportable by the US Air Force, it must not exceed an axle load of 13,000 lbs anywhere on the ramp. To achieve this goal, the Hydrema vehicle has 2 bogie wheels that are installed just to load the vehicle onto the aircraft.

2.0 TEST SETUP

2.1 Test Equipment

In order to monitor the weight of a vehicle as it is loaded into a C-130, two axial load measurement ramps have been designed, fabricated, and instrumented with load cells (See Figure 1). The load cells are wired to a data acquisition system and data is sampled continuously while the vehicle is loaded on and off the ramp. The ramp has 16 instrumented plates (A-P in Figure 1), that are 32" square. Each plate has four 5,000 lb load cells, one in each corner. This allows each plate to record loads up to 20,000 lbs. The load cells are wired to a summing box, also located on the bottom of the plate, where the readings from all 4 load cells are added together and sent to the data acquisition system. The plates can be reconfigured to take measurements as the vehicle climbs the ramp, on the floor of the plane, or a combination of both. The ramp angle can be changed from 12 to 15 degrees.

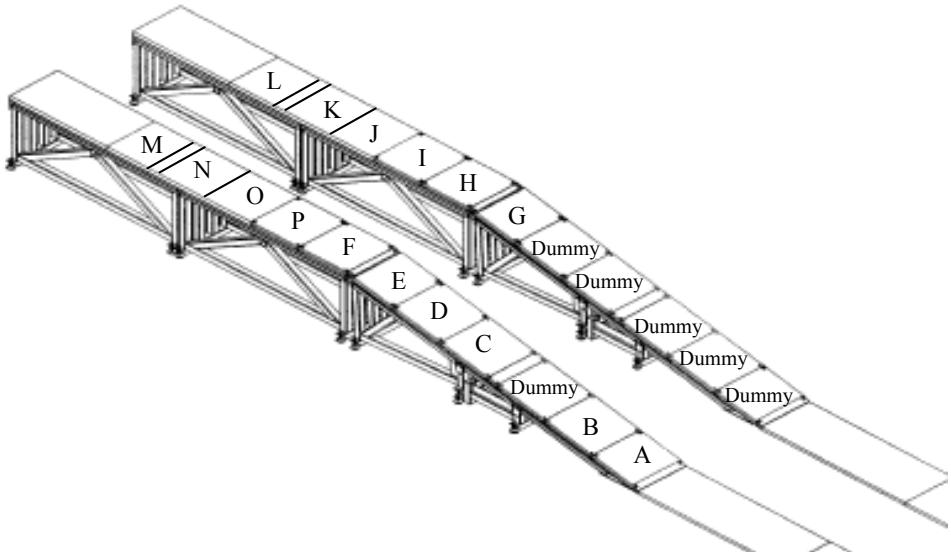

Figure 1. C-130 Measurement Ramps

2.2 Vehicle Configuration

The Hydrema MCV is a four wheeled vehicle that weighs over 35,000 lbs. In order to spread out this weight, a special bogie wheel system is mounted on the vehicle and controlled hydraulically (Figure 2). It is believed that this bogie axle will allow the Hydrema to meet the 13,000 lb axle limit.

Figure 2. Hydrema Bogie Axle Assembly

The Hydrema also has its flail system rotated and stowed on the rear of the vehicle (Figure 3). All the chains and hammers for the system have been removed for transport.

Figure 3. Stowage of flail system

2.3 Test Procedure

The test plan is to drive the Hydrema up the ramp 3 times with the ramp at 12 degrees and 3 times with the ramp at 15 degrees. Due to small changes in position and alignment, the weight changes slightly from run to run. The final weight was obtained by taking the average of the three runs.

Past ramp testing has shown that most vehicles have peak axle loads at or near the hinge pin. This is where the top of the ramp is connected to the fuselage of the aircraft. The vehicle will pause just before first contact with the hinge pin, at first contact, and when the tire is centered on the hinge pin. These pauses will be watched closely for the first axle and the bogie axle. It is believed that as the bogie crosses over the hinge pin is where the heaviest weight will be recorded.

Table 1. Description of test runs.

Test Number	Description of test run.
3	Normal test run at 12 degrees
4	Normal test run at 12 degrees
5	Normal test run at 12 degrees with plate L relocated to the bottom of right ramp
6	Run at 12 degrees without bogie engaged
7	Run at 15 degrees without bogie engaged
8	Normal test run at 15 degrees with plate L relocated to the bottom of right ramp
9	Normal test run at 15 degrees
11	Normal test run at 15 degrees
12	Run at 15 degrees with plate B relocated to the bottom of the right ramp
13	Run at 15 degrees with plate B relocated to the bottom of the right ramp

3.0 Results

A total of 10 test runs were completed. Table 1 has a short description of each run. Tests 1, 2, and 10 were practice runs and were not included in the data analysis. Spreadsheets containing all of the data of interest can be found in the Appendix section of the report. The data for the normal test runs completed with the ramp at 12 degrees are in Appendix A, and the normal runs completed with the ramp at 15 degrees are in Appendix B. Tests 6 and 7 were added during testing to see what effect not having the bogie axle would have on the weight of the front and rear axle. The data for runs 6 and 7 is found in Appendix C. Tests 12 and 13 were added due to a problem with plate L not reading weights above 7,000 lbs. The problem was found in the software after testing and has been corrected. Data for these runs can be found in Appendix D.

The data shows that with the ramp at 12 degrees the Front Axle and Bogie Axle are below the 13,000 lb axle limit when they cross the hinge area. However, while running the first 2 runs at 12 degrees, it was observed that larger weight spikes were appearing near the base of the ramp. In order to capture the weight of the vehicle on both sides at the base of the ramp, plate L was moved from its original location to the bottom of the right ramp across from plate A. The third run at 12 degrees then verified that the largest axle loads were occurring at the bottom of the ramp on all 3 axles. All 3 axles were seeing over 15,000 lb loads at the base of the ramp. Further data analysis also shows that the Rear Axle after entering the plane averaged over 14,000 lbs.

The data with the ramp at 15 degrees shows that the Bogie Axle and the Rear Axle are above the 13,000 lb axle limit near the hinge pin. It also shows that all 3 axles are over the limit at the bottom of the ramp and the Rear Axle is over the limit just inside the aircraft.

Runs 6 and 7 were completed without the use of the bogie axle. Without the bogie axle in place, both axles are well over the 13,000 lb axle limit at both ramp angles. Runs 12 and 13 show that all three axles are also well over the axle limit at the base of the ramp.

4.0 Conclusion

Reviewing the data for the 12 degree ramp runs, the vehicle fell short of meeting the 13,000 lb axle limit. The problem areas are at the base of the ramp and just onto the floor of the plane. All three axles are too heavy at the base of the ramp and the rear axle is too heavy when it rolls into the aircraft.

The 15 degree ramp runs show even more problem areas. Here the bogie axle and the rear axle as it approaches the hinge pin also exceeded the 13,000 lb axle limit.

During runs 12 and 13, it appeared that a large amount of the front axle's weight shifted to the left side of the vehicle (See Appendix D). A quick operational check was performed on plate A showed that it was reading the 2,050 lb weight used for calibration correctly. This situation needs to be addressed before future testing begins.

Also of interest, during some of the test runs, three of the instrumented plates appeared to saturate after reaching specific weights. This problem was addressed during analysis of the data. It was discovered that the active ranges for these channels were not set properly. Changes have been made to the test setup and this problem will not be repeated.

Future testing should expand the number of test runs and collect data slightly differently. It is suggested that 6 runs be completed for each ramp angle. The first 3 runs can be completed with instrumented plates covering the entire angled portion of the ramp. The next 3 runs will have the upper portion of the ramp completely instrumented. This will show us the axle weights of the vehicle on the floor of the plane.

Appendix A
Ramp data recorded at 12 degree angle.

12 degree ramp data ** All axle weights are in lbs.

	left	right	total	
Axle 1 just before hinge				
run #3 normal run	5124	5693	10817	Average weight
run #4 normal run	5110	5570	10680	10835.67
run #5 normal run	5550	5460	11010	
Axle 1 @ hinge				
run #3 normal run	4920	6316	11236	Average weight
run #4 normal run	5029	5466	10495	10814.33
run #5 normal run	5233	5479	10712	
Axle 1 on hinge				
run #3 normal run	4387	6190	10577	Average weight
run #4 normal run	4572	5810	10382	10415
run #5 normal run	4646	5640	10286	
Bogie Axle before hinge				
run #3 normal run	6590	5540	12130	Average weight
run #4 normal run	6170	5590	11760	12043.33
run #5 normal run	6640	5600	12240	
Bogie Axle @ hinge				
run #3 normal run	6550	5500	12050	Average weight
run #4 normal run	6292	5756	12048	12090.67
run #5 normal run	6674	5500	12174	
Bogie Axle on hinge				
run #3 normal run	6160	5440	11600	Average weight
run #4 normal run	5650	5590	11240	11430
run #5 normal run	5870	5580	11450	
Axle 1 at bottom of ramp				
run #5 normal run	8450	6710	15160	
Bogie Axle at bottom of ramp				
run #5 normal run	9060	7110	16170	*right side plate L saturated
Axle 2 at bottom of ramp				
run #5 normal run	7990	7110	15100	*right side plate L saturated
Axle 2 wt just inside plane				
run #3 normal run	6330	8110	14440	Average weight
run #4 normal run	6210	8180	14390	14350
run #5 normal run	6040	8180	14220	

Appendix B
Ramp data recorded at 15 degree

15 degree ramp data ** All axle weights are in lbs.

	left	right	total	
Front Axle just before hinge				
run #11 normal run	3960	4760	8720	Average weight
run #9 normal run	4320	5020	9340	8853.33
run #8 normal run	4260	4240	8500	
Front Axle @ the hinge				
run #11 normal run	3670	5010	8680	Average weight
run #9 normal run	4010	5410	9420	8923.67
run #8 normal run	3956	4715	8671	
Front Axle on the hinge				
run #11 normal run	4030	5330	9360	Average weight
run #9 normal run	4250	5700	9950	9556.67
run #8 normal run	4070	5290	9360	
Bogie Axle just before hinge				
run #11 normal run	6320	6590	12910	Average weight
run #9 normal run	7530	8090	15620	14650.00
run #8 normal run	7800	7620	15420	
Bogie Axle @ the hinge				
run #11 normal run	7550	7870	15420	Average weight
run #9 normal run	7530	8090	15620	15486.67
run #8 normal run	7800	7620	15420	
Bogie Axle on the hinge				
run #11 normal run	7320	8670	15990	Average weight
run #9 normal run	7390	8440	15830	15966.67
run #8 normal run	7840	8240	16080	
TEST RUN NUMBER 11				
Rear Axle wt before hinge	8250	8620	16870	
Rear Axle wt @ hinge	8015	8660	16675	
Rear Axle wt on hinge	7050	8550	15600	
Front Axle wt at bottom of ramp				
run #8 normal run	8780	6440	15220	
Bogie Axle wt at bottom of ramp				
run #8 normal run	10900	6940	17840	
Rear Axle wt at bottom of ramp				
run #8 normal run	7890	6940	14830	
Rear Axle wt just inside plane				
run #11 normal run	6070	8080	14150	Average weight
run #9 normal run	6130	8160	14290	14286.67
run #8 normal run	6450	7970	14420	

Appendix C
Test runs without bogie axle engaged

Test runs without bogie axle engaged ** All axle weights are in lbs.

	Left	Right	Total	
Front Axle at base of ramp				
Ramp at 12 degrees	9650	7090	16740	rt side saturated
Ramp at 15 degrees	9990	6940	16930	rt side saturated
Rear Axle at base of ramp				
Ramp at 12 degrees	10300	7090	17390	rt side saturated
Ramp at 15 degrees	9880	6940	16820	rt side saturated
Front Axle just before hinge				
Ramp at 12 degrees	7650	7480	15130	
Ramp at 15 degrees	6146	7000	13146	
Rear Axle just before hinge				
Ramp at 12 degrees	9580	10300	19880	
Ramp at 15 degrees	9370	10100	19470	
Rear Axle just inside plane				
Ramp at 12 degrees	7340	9460	16800	
Ramp at 15 degrees	7680	9680	17360	

Appendix D

Test runs at 15 degrees with plate B at bottom of right side of ramp.

Data with plate B at bottom of right ramp
Ramp at 15 degrees

** All axle weights are in lbs.

Front Axle at base of ramp	Left	Right	Total
Run 12	9190	5590	14780
Run 13	9330	5550	14880
Bogie Axle at base of ramp			
Run 12	8760	8660	17420
Run 13	9480	10200	19680
Rear Axle at base of ramp			
Run 12	7850	9060	16910
Run 13	7800	8330	16130